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Energy Procedia 17 (2012) 1717 – 1723

Energy Procedia

2012 International Conference on Future Electrical Power and Energy Systems

New Viewpoint of Foundation Stability of Newly Building upon Goaf

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Abstract

Foundation deformation of new buildings upon old mined out area and the survival subsidence and deformation of old goaf had been studied by similar material model in the paper. When additional stress caused by building foundation reached a thick hard rock sandstone stratum, the vertical deformation was blocked while horizontal deformation expanded significantly. The actual influence depth of ground loading is obvious smaller than theoretical result. The spread depth of building load upon mined out area is related with the disturbed degree by mining, the ground loads spread depth is greater with the increase of disturbance degree. After passed through key strata and caused overburden stratum separation closed, the additional stress caused by ground foundation would quickly reach inside of goaf, caused movement and deformation on strata upon goaf. But the movement and deformation is relied to the situation of goaf, there would not significant activation in all mined out areas.

Keywords:foundation; goaf; key strata; remnants deformation;

1. Introduction

In order to improve energy efficiency and increase the additional value, the development trend of coal is to divide it into some more useful energy sources in place, which calls for processing constructions around coal mines. On the other hand, the shortage of building land is becoming more and more serious in our country, which made it a good way to solve the conflicts of cropland and building land that making abandoned ground upon goafs as building land.

Some deformation had occurred on the ground upon old goafs, and the deformation would continue for a long period time with the influence of mined area [1, 2]. With the influence of newly buildings, the

 doi:10.1016/j.egypro.2012.02.303

subsidence law of mining disturbed foundation is different from that of nature foundation. Notable foundation deformation may occur when the space on mined area releasing with the effect of newly buildings [3, 5]. So in order to ensure the building safety upon goaf, the foundation stability must be evaluated first.

The evaluating standard of foundation stability upon goaf is widely used is that the ground load does not spread to the depth of overburden crack belt, which has been considered notable deformation will not happen on foundation, and new buildings upon goaf is safe[2,4]. But further research need to be done in order to get the reliability of this evaluating standard. Based on simulate material method, foundation deformation on different locations of goaf due to different load had been monitored, and some useful conclusions had been obtained.

2. Similar material model and monitoring method

Based on the geological and mining conditions in Yanzhou mining area, a long wall mining similar material model had been established, with the scale of 1:200, mining depth 180m, coal seam 3.0m and advanced distance 400m. The distribution and description of strata is showed in table 1.

Table 1 Coal and strata description of simulated material model

Seam number	Seam name	Thickness /m	Density /(kg/m^2)	Compressive strength(MPa)
1	soil	20	2100	
2	sandstone	30	2693	27.7
3	marlite	50	2550	12.7
4	sandy shale	14	2630	37.2
5	limestone	4	3139	87.8
6	shale	2	2650	20.0
7	hardpan	10	2590	54.7
8	flexible sandstone	26	2664	76.2
9	coal	4	2400	0.9
10	hardpan	20	2590	54.7
11	shale	20	2650	20.0
12	coarse-grained sandstone	20	2550	91.2

The load upon goaf was imposed by air press on strip foundation, and the ground deformation measured by photographic method, with the monitor accuracy of which is 0.003~0.005mm to meet the requirements of deformation monitoring of similar material model. The layout of monitoring points on similar model was showed in (Fig.1).

The big points on fig.1 are control points, which of them on frame are used to compare the deformation of different loads and the other of them on model are used to get the photos of same load together. The small points of the figure are used to measure the deformation. One row monitoring points is arranged in a thin stratum, and two rows of which is arranged in a thick stratum. The ground load imposed by step manner with the location on outboard of goaf, inboard edge of goaf and the center of goaf.

Sponsored by State Environmental Projection Fund for Non-profit Industry specific (Project number:200809128) and Qing Lan Project.

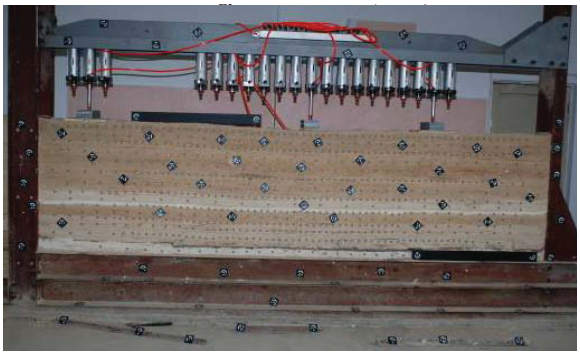

Fig. 1 layout of monitoring points on similar material model

Through monitoring and data processing, the conclusion that the maximum height of overburden crack belt is 78m and the height of overburden stratum separation is 128m had been got. The distance between overburden crack belt and ground is 100m, and which between overburden stratum separation and ground is 50m.

3. Analysis of ground load spread depth

3.1 The theoretical and measured result of maximum spread depth of ground load

Generally, the influence of additional stress of foundation can be ignored in the depth where the additional stress caused by foundation is 20% of gravity stress. If there are unstable soil factors, such as mined area and karst, the depth should be calculated to the position where additional stress caused by foundation is 10% of gravity stress. The depth is the influence depth of building foundation. Among them, the gravity stress can be calculated:

$$\sigma_c = r_1 h_1 + r_2 h_2 + \cdots + r_n h_n$$

Where,

Y_1, Y_2… Y_n are density of soil or rock stratum, kN/m3;

h_1, h_2… h_n are thickness of soil or rock stratum, m;

Additional stress caused by foundation can be calculated as follow:

$\sigma_Z = kP_0$

Where,

k is the vertical additional stress coefficient of loads, which can got from Engineering Geology Reference Manual;

P_0 is the average additional stress on the bottom of foundation, KN/ m^2.

The maximum spread depth of different loads was shown in table 2, while the measured maximum depth of the same load was compared.

TABLE 2 comparison of the maximum depth of different loading

Influence Depth (m) Loading Size (MPa) / Result Type	Academic result	Measured result
0.05	25	20
0.1	38	20
0.15	46	20
0.2	53	38
0.25	58	45
0.3	64	50
0.35	68	50
0.4	71	50
0.45	75	50
0.5	78	180(contacted with
0.6	82	mining goaf)
0.7	85	

The conclusion that maximum spread depth of measured result is significantly less than which of theoretical results before they spread to overburden stratum separation can be got from table 2. The reasons can be analyzed from the following aspects:

When theoretical calculating, the strata were considered as homogenization soil layers, and only the bulk density of them had been used whereas other mechanical properties such as compressive strength had been ignored. And in similar material model, physical and mechanical strength of different strata is different, and the strength of most of them is higher than soil. So, the measured influence depth of loads was less than theoretical spread depth of which.

In the measured result, there are two distinct boundary positions of ground foundation spread depth, which of them are 20m and 50m. Compared with the strata distribution in table 1, the message that the stratum between 20m and 50m is hard rock sandstone could be got. Therefore, the same as mining deformation pass through upper strata; key strata also exist to counterwork deformation when foundation stress spread down. When additional stress caused by building foundation reached a key stratum, the vertical deformation is blocked while horizontal deformation expanded significantly. The key stratum would be broke when the stress on it increased to a certain quantity, then the spread depth of ground foundation would increased dramatically until it reached the ultimate depth or prevented by another key stratum.

3.2 Foundation stress spread depth on different position of goaf

The disturbed degree of foundation soil is different in different position of goaf, which caused the different of spread depth of additional stress caused by ground load. The spread depths of different load on the outboard of goaf, on the center of goaf and on the inboard edge of goaf were monitored, with the results was shown in table 3.

Table 3 ground foundation influence depth with the relative position of goaf

Influence Depth (m) / Loading Position / Loading Size (MPa)	**Load on the outboard of goaf**	**Load on the center of goaf**	**Load on the inboard edge of goaf**
0.05	6	20	12
0.1	8	20	20
0.15	16	20	20
0.2	24	38	32
0.25	32	45	38
0.3	38	50	45
0.35	45	50	50
0.4	50	50	50
0.45	50	50	50
0.5	50	180(contacted with mining goaf)	
0.6	65		
0.7	68		

The influence of ground foundation on depth gradual decreased along with the position far away from the central location of mined areas. According to the surface deformation procession of coal mining rules, the disturbance degree of soil caused by mining also decreased with the position far away from central location of mined areas. So, the influence depth of ground loads related with the disturbance degree of soil caused by mining, the ground loads spread depth is greater with the increase of disturbance degree. The broke phenomena of key strata on spread depth was obvious in any position.

3.3 New standard of the influence of ground foundation on goaf

Previous research showed that notable deformation will occur on foundation and strata when ground load spread to the depth of overburden crack belt, but the monitored data of the similar material model showed a different outcome. In the model, after passed through a key stratum and caused overburden stratum separation closed, the additional stress caused by ground foundation would quickly reached inside of goaf, caused movement and deformation on strata upon goaf. The strata movement in different position with the ground load of 0.5Mpa was shown in (Fig. 2) by model scale.

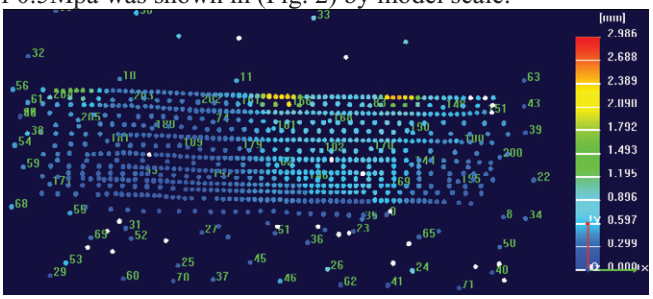

Fig. 2 Deformation of monitor points with additional stress of 0.5MPa

Thus, the disturbance degree on goaf caused by ground load should be analyzed with the key strata situation, rather than using the evaluation criteria that ground load had been spread to the depth of overburden crack belt or not.

4. Additional deformations on ground

The ground foundation deformations on different load had been got by the analysis of monitor data. The experimental results and theoretical calculated results of maximum subsidence of ground foundation with different loads were shown in Table 4. Where, the theoretical maximum subsidence results can be calculated by:

$$s = \phi_s \sum_{i=1}^{m} \frac{p_0}{E_{\theta i}} (z_i \overline{\alpha_i} - z_{i-1} \overline{\alpha_{i-1}})$$

Where

s is the final subsidence of foundation, mm. The meanings of other parameter can be found in reference [6].

Table 4 comparison of maximal foundation subsidence

Result / Type / Maximum Subsidence (mm) / Loading Size (MPa)	**Academic result**	**Measured result**
0.05	9	8
0.1	261	207
0.15	395	235
0.2	578	264
0.25	737	291
0.3	904	369
0.35	1070	383
0.4	1236	441
0.45	1411	497
0.5	1585	602
0.6	1928	792
0.7	2273	1117

In this model, because there was only few spaces in the long wall mined old goaf, notable deformation was not occurred on mined area when ground loads spread to goaf, the compaction of residual space caused very little movement and deformation on ground foundation. With the influence of old mined area, the maximum measured subsidence of ground foundation even smaller than the calculated results by theoretical method without goaf.

Thus, the analysis of residual deformation of new buildings upon old goaf should consider the subsidence and deformation had been happened in the area. If a long wall mining face had been mined a long time and great deformation had been occurred when mining to leave few spaces on mined area, the additional deformation of old goaf caused by new building was small, which would not effect the foundation stability obviously. In this case, the foundation could be treated as soft soil.

5. Summary and conclusion

Foundation deformation of new buildings upon old mined out area and the survival subsidence and deformation of old goaf had been studied by similar material model in the paper, and some useful conclusions had been made.

There are key strata to influence the spread of foundation land on depth. When additional stress caused by building foundation reached a thick hard rock sandstone stratum, the vertical deformation was blocked

while horizontal deformation expanded significantly. The actual influence depth of ground loading is obvious smaller than theoretical result.

The spread depth of building load upon mined out area is influenced by mining disturbed degree. In the high disturbed area such as the center of goaf, the additional stress caused by new building foundation spread deeper than which on the place far away from goaf.

After passed through key strata and caused overburden stratum separation closed, the additional stress caused by ground foundation would quickly reach inside of goaf, caused movement and deformation on strata upon goaf. But the movement and deformation is relied to the situation of goaf, there would not significant activation in all mined out areas.

References

[1]Yan Ronggui. Foundation subsidence caused by mining and surface construction. Beijing: Metallurgical Industry Press, 1995 (in Chinese)

[2]Teng Yonghai, Zhang Junying. Evaluation on stability of building foundation over goafs. Journal of China Coal Society, 1997, 22 (5): 504~508. (in Chinese)

[3]ZHANG Wen quan,LU Yu hua, atc. Analysis and Evaluation of the Surface Settlement and Builing s Stability above Old Workings. Journal of ShanDong INST. Of MIN&TECH, 1999, 1(3): 19~22. (in Chinese)

[4]Zhang Junying, The laws of overlying strata influenced by newly increased load on the surface above worked-out area. Journal of china coal society, 2008,33(2),116-120. (in Chinese)

[5]Guo Guangli, Deng Kazhong, atc. Study on the foundation settlement of heavy buildings above mine goafs. Jounral of China University of Mining& Technology, 1996, 25 (2): 54~57. (in Chinese)

[6]Writing Group of Engineering Geology manual, engineering geology manual, China Building Industry Press, 1992. (in Chinese)